MISSE PEACE Polymers: An International Space Station Environmental Exposure Experiment Being Conducted

As part of the Materials International Space Station Experiment (MISSE), 41 different polymers are being exposed for approximately 1 1/2 years to the low-Earth-orbit (LEO) environment on the exterior of the International Space Station. MISSE is a materials flight experiment sponsored by the Air Force Research Lab/Materials Lab and NASA, and is the first external experiment on the space station. A similar set of 41 polymers will be flown as part of the Polymer Erosion and Contamination Experiment (PEACE) a shuttle flight experiment that is being developed at the NASA Glenn Research Center collaboratively with the Hathaway Brown School for girls. Therefore, these 41 polymers are collectively called the MISSE PEACE Polymers. The purpose of the MISSE PEACE Polymers experiment is to determine how durable polymers are in the LEO space environment where spacecraft, such as the space station, orbit. Polymers are commonly used as spacecraft materials because of their desirable properties such as good flexibility, low density, and certain electrical properties or optical properties (such as a low solar absorptance and high thermal emittance). Two examples of the use of polymers on the exterior of spacecraft exposed to the space environment include metalized Teflon FEP (fluorinated ethylene propylene, DuPont) thermal control materials on the Hubble Space Telescope, and polyimide Kapton (DuPont) solar array blankets.

Atomic oxygen is the predominant species in LEO (below 1000 km), and spacecraft surfaces, such as polymers, that literally ram into the resident oxygen atoms are oxidized. Because the oxidation product for most polymers is a gas, atomic oxygen erosion results. Over time, complete loss of the polymer can occur if it is not properly protected. In addition to the obvious potential degradation to the structural stability of polymers, thin polymer thermal control materials are also threatened by atomic oxygen erosion because thermal emittance depends on polymer thickness. Therefore, the specific goal of the MISSE PEACE experiment is to accurately determine the atomic oxygen erosion yield of a wide variety of polymeric materials.

Glenn invited high school students from the PEACE Team, along with some university students, to collaborate on the Glenn MISSE PEACE Polymers experiment. The polymers in the MISSE PEACE Polymers experiment range from those commonly used for spacecraft applications, such as Teflon FEP, to more recently developed polymers, such as high-temperature polyimide PMR (polymerization of monomer reactants). Polymers that are not desired for spacecraft applications are also included solely on the basis of their chemical composition. The erosion yield data obtained from this experiment will be compared with data obtained from the short-duration experiment PEACE, and with ground data. The LEO erosion yield data will be compared with erosion yield predictions

made by Integrity Testing Laboratory, Inc. These predictions are made on the basis of predictive models using information about the chemical composition, structure, and densities of polymers, as well as Oxygen Index data. Having the erosion yield data for many different polymers, all characterized and exposed to space under identical conditions, and having space data to compare with the predictive model, will be very useful to spacecraft designers in the future.

During a spacewalk on August 16, 2001, astronaut Patrick Forrester installs the Materials International Space Station Experiment (MISSE) on the International Space Station's Quest Airlock, the first external experiment on the station's hull.

MISSE is a cooperative effort among the Air Force, NASA, and industry that underwent integration at Boeing, the NASA Marshall Space Flight Center, and the NASA Langley Research Center. It consists of 1- and 3-year exposure trays to be exposed to both atomic oxygen and solar radiation (in addition to other environmental exposures), or to solar radiation with no atomic oxygen exposure. The PEACE Polymers are on one of the two 1-yr MISSE Passive Experiment Carriers being exposed to both atomic oxygen and solar radiation. On August 16, 2001, astronauts Dan Barry and Patrick Forrester attached the two MISSE Passive Experiment Carriers (PEC's) to separate handrails on the exterior of the International Space Station airlock during a successful extravehicular activity, or space walk. NASA plans to retrieve MISSE in the fall of 2002.

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